4.0 PHASE 1 HIGH-LEVEL WASTE FEED STAGING

The Phase 1 privatization contract establishes specific requirements for the delivery of HLW feed to BNFL Inc. These requirements provide objectives for retrieval, staging and delivery of HLW slurry. To meet these objectives, a staging scenario identified as Case 3S6E was evaluated by computer simulation. Results and conclusions of the evaluation are discussed in this section. Case 3S6E implements final planning guidance (PIO 2000) and therefore supersedes previous cases.

4.1 HIGH-LEVEL WASTE FEED STAGING SCENARIO

The staging approach for Case 3S6E is to provide reliable feed delivery to BNFL Inc. while meeting privatization contract requirements. The number and location of staging tanks selected for Case 3S6E improve the reliability of HLW feed delivery by providing backup staged feed capability from independent tank farms. Feed staging capability is provided from AZ, AY, and AW tank farms to minimize the probability of a single-point failure in the delivery system resulting in loss of feed capability.

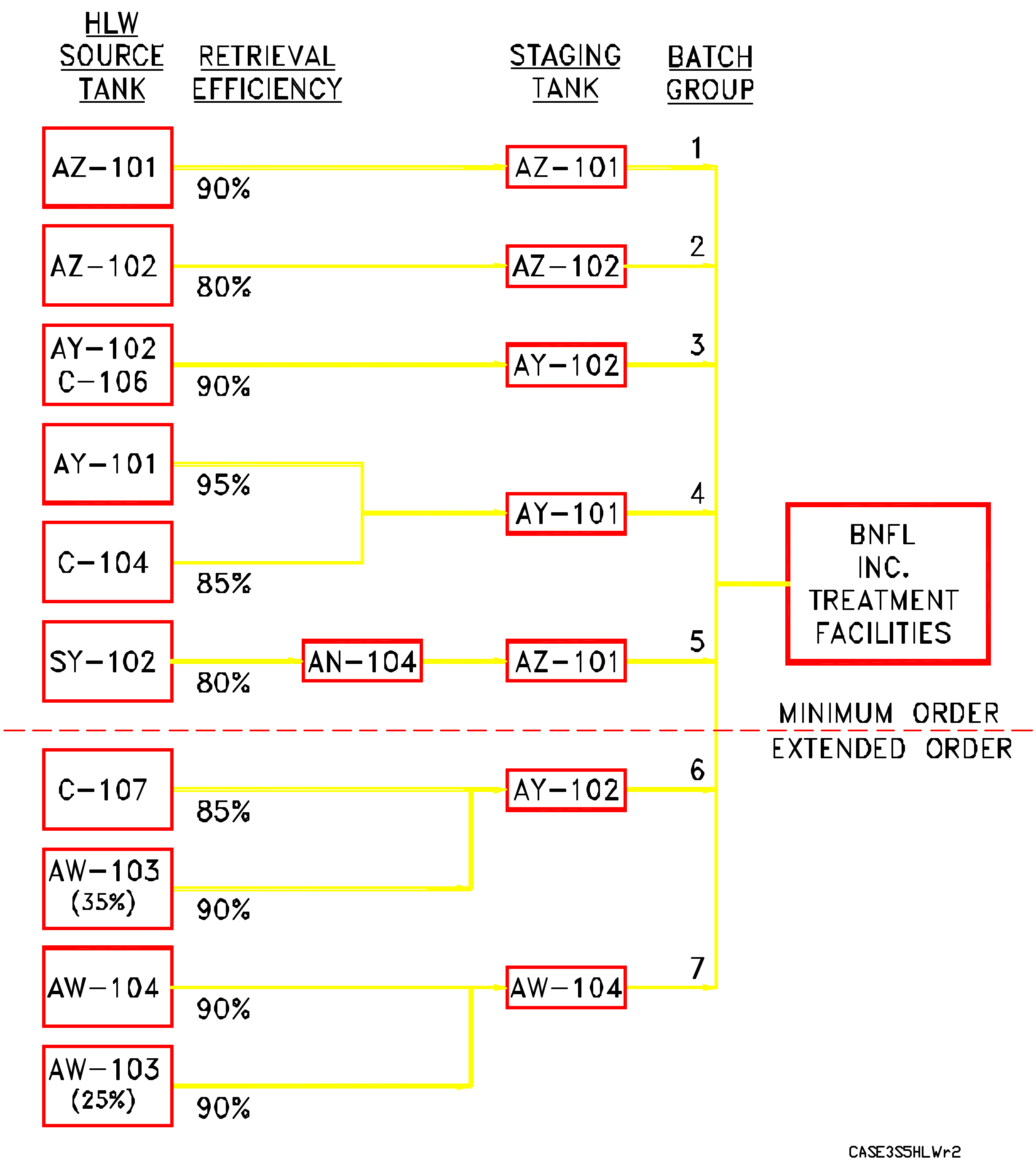
Identification of HLW source and staging tanks for Case 3S6E Phase 1B is shown in Figure 4.1-1. Phase 1B HLW source tanks were specified by ORP (1999). Case 3S6E uses HLW from five DSTs and one SST (241-C-104) to meet the minimum order quantity of 600 canisters of IHLW plus a contingency of 365 canisters of IHLW. Waste from two DSTs and one SST provides HLW feed in the extended order of Phase 1. Tanks 241-AZ-101, 241-AZ-102, 241-AY-101, and 241-AY-102 are used as staging tanks with 241-AW-103 prepared as a backup staging tank.

Several batches of slurry are delivered from a single staging tank of HLW feed. This group of individual batches delivered from a staging tank is referred to as a batch group. Five batch groups constitute the minimum order Phase 1B HLW feed. Wastes from individual source tanks 241-AZ-101, 241-AZ-102, 241-AY-102/241-C-106, and 241-SY-102 are staged unblended to make Batch Groups 1, 2, 3, and 5. Waste from source tank 241-C-104 is blended in tank 241-AY-101 to make Batch Group 4. Two batch groups constitute the Phase 1B extended order HLW feed. Waste from SST 241-C-107 is blended with a portion of the waste from 241-AW-103 in 241-AY-102 to make Batch Group 6. A portion of waste from 241-AW-103 is blended in 241-AW-104 to make Batch Group 7.

Feed delivered from each batch group is discussed in Section 4.1.1. Information on IHLW glass products is shown in Section 4.1.2. The composition of each feed batch group is compared against contract specifications in Section 4.1.3.

The tank-specific staging plan, the retrieval and transfer equipment needed to support the staging plan, and the work execution schedule are discussed in Section 4.2. The waste transfers and certain precedent relationships directly needed to implement the HLW portion of the operating scenario are shown on the MSD in Section 3.2.3. Waste volume plots with denoted transfers as a function of time for all Phase 1 DSTs are also provided in Section 3.2.3.

Figure 4.1-1. High-Level Waste Feed Staging – Case 3S6E.



HLW = High-level waste.

A full description of all Phase 1 transfers, including dates, volumes, and destinations, is included in Appendix H.

4.1.1 High-Level Waste Feed Delivery

The baseline HLW operating scenario refers to the waste transfers and other operational activities needed to deliver HLW feed to BNFL Inc. The major bases and assumptions governing this operating scenario are discussed in Appendix A. The feed delivery plan is summarized in Table 4.1-1.

The quantity of unwashed solids delivered will depend on retrieval efficiency. The expected DST retrieval efficiencies are 95 percent for 241-AY-101; 90 percent for 241-AZ-101, 241-AY-102/C-106, 241-AW-103, and 241-AW-104; 80 percent for 241-AZ-102 and 241-SY-102. In addition, a retrieval efficiency of 85 percent was assumed for SSTs 241-C-104 and 241-C-107. To ensure that enough unwashed solids are delivered to BNFL Inc. to produce 600 HLW glass canisters, the expected retrieval efficiencies are used for planning purposes instead of the assumption that 100 percent of the waste is retrieved.

Supplemental retrieval systems should be implemented with mixer pumps in tanks 241-AW-103 and 241-SY-102 to increase retrieval efficiencies. Retrieval efficiencies shown above for these tanks assume that the supplemental retrieval systems are implemented. Modeling of the effective cleaning radius (ECR) of two mixer pumps alone in these tanks predicts low retrieval efficiencies as a result of the high shear strength of the sludge. A newer ECR model shows a lower dependence of shear strength on the effective cleaning radius of mixer pumps, but the model cannot be validated yet because of inadequate data on waste viscosity. As viscosity data become available through laboratory measurements of tank samples, the newer ECR model will be re-evaluated.

Table 4.1-1 summarizes, by batch group, quantities of liquids, unwashed solids, and sodium delivered to BNFL Inc. by batch group. Batch Groups 1 though 5 are delivered to meet the minimum order quantity and Batch Groups 6 though 7 are delivered for the extended order. Approximately 2,100 MT of unwashed solids will be delivered during Phase 1. This quantity represents a 30-percent decrease from the quantity of solids projected in revision 1 of the TFC O&UP. The decrease in delivered solids is due primarily to two factors. The number of source tanks decreased from ten to seven and the inventory changed significantly in tank 241-AY-101.

The source feed for the first three HLW batch groups exist in the staging tanks. Timing for staging of the first three batch groups is determined by (1) project schedules for providing equipment required for mixing and feeding and (2) sampling and sample analysis necessary for feed certification.

Overall timing for staging the remaining feed batch groups is determined by the assumed HLW processing rates, waste oxide loading in the IHLW glass, and the quantity of waste oxides in the feed. Knowledge of actual processing rates, including the planned ramp-up, is important for establishing the final timing for these feed batches.

In general, sources of HLW slurry are retrieved and transferred to the HLW staging tanks as soon as the HLW staging tank is emptied of its previous batch. The waste is mixed and sampled for certification before delivery to BNFL Inc.'s feed receipt tanks. The certification process and requirements for feed transfer from the HLW staging tank to BNFL Inc.'s feed receipt tanks are specified in ICD-20 (BNFL 2000). The overall operating logic and timing for the certification and delivery of a single batch of feed is shown in Figure 4.1-2.

There are several authorization basis issues associated with consolidation and storage of HLW solids. Some examples of these issues are tank bumps, aerosol generation, and changes in source terms for several types of accidents. These issues were identified and evaluated in Grams et al. (1997), and were further addressed in subsequent evaluations and studies (Ryan 2000).

4.1.2 Projected High-Level Waste Product

Based on expected retrieval efficiencies described previously, the expectation is that 965 IHLW glass canisters will result from the treatment of waste in Batch Groups 1 through 5, the minimum order quantity tanks. An additional 465 canisters of IHLW would be produced by the extended order tanks, with approximately 95 of the canisters produced by the end of the Phase 1 contract period in February 2018. The remaining waste is staged as contingency feed. This amount of IHLW glass includes a 57-canister incremental increase resulting from the blending of strontium and manganese precipitates with HLW feed. The precipitates result from the pretreatment of Envelope C waste feed originating in tanks 241-AN-107 and 241-AN-102. The precipitates are blended with waste from tanks 241-AY-102/241-C-106 and 241-AY-101/241-C-104 because of the time-phased processing of LAW and HLW. The time-phased processing of waste from these LAW and HLW feed tanks is best illustrated in Figure 3.2.1. The calculations used for IHLW glass canister projections assumes water washing of sludge from tanks 241-AZ-101 and 241-AZ-102, and caustic washing of the remaining HLW tanks in both Phase 1 and Phase 2. Utilization of only water washing of all HLW feed would be expected to produce more IHLW glass. The product contains 1.15 m^3 of glass in a 95-percent-full canister at a glass density of 2.66 MT/m^3.

For each batch group, Table 4.1-1 summarizes source tanks, staging tank, mass of waste oxides, waste oxide loading (WOL), mass and volume of glass, and the number of canisters of IHLW. Waste oxide loadings are calculated by means of a glass properties model. Waste oxide loading is defined as the mass of non-volatile waste oxides excluding oxides of sodium and silicon divided by the total mass of glass. Oxide loadings calculated from the glass properties model are higher than would result from just meeting minimum WOL as defined in Specification 1 of the BNFL Inc. contract. A detailed discussion of the potential effects of relatively large differences in WOL is provided in TWRSO&UP, Revision 1 (Kirkbride et al. 1999), Appendix G. To ensure that enough HLW slurry is delivered for BNFL Inc. to produce 600 IHLW canisters, the glass properties model is used for planning purposes to calculate WOL and volumes of glass. The WOL in Batch Groups 1 and 2 is limited by the spinel liquidus temperature with iron oxide loadings of 11.6 wt% and 14.3 wt% respectively. An iron oxide concentration of 15 wt% limits the oxide loading in Batch Group 3. Batch Group 4 is limited by both the spinel and zirconia liquidus temperatures (1050 ºC).

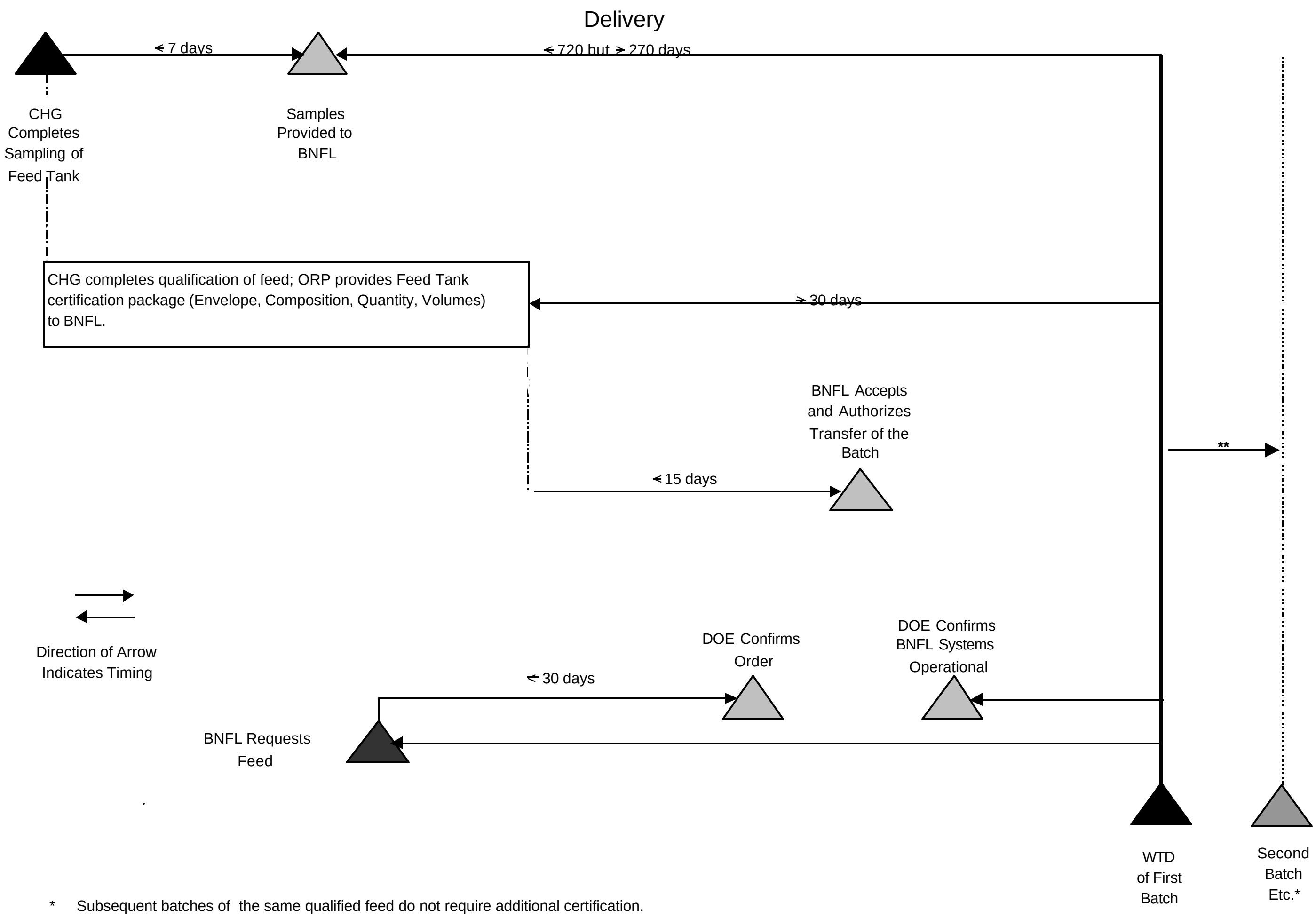
Table 4.1-1 Summary of High-Level Waste Feed Staging and Delivery - Case 3S6E - R2A

Batch group	Batches	Feed source	Staging tank	Dates[a]						Delivered Feed				Expected IHLW Product - Glass properties model[f]						Maximum IHLW Product - Specification 1[g]					
				Start retrieval	Begin staging	First batch ready[b]	Start delivery	Start of vitrification	End of vitrification	Liquids (ML)	Solids[c] (MT)	Volume[d] (ML)	Radioactivity[e] (Ci)	Non-volatile waste oxides[h] (MT)	Waste oxide loading[i] (%)	Mass of HLW glass (MT)	Volume of HLW glass[j] (m^3)	Number of HLW canisters[k]	Cumulative HLW canisters[k]	Non-volatile waste oxides[h] (MT)	Waste oxide loading[i] (%)	Mass of HLW glass (MT)	Volume of HLW glass[j] (m^3)	Number of HLW canisters[k]	Cumulative HLW canisters[k]
Privatization Phase 1 Minimum Order																									
1	1-6	AZ-101	AZ-101	--	--	2/28/2006	9/1/2006	9/1/2008	12/31/2009	3.02	102	3.05	9.42E+06	83.7	30.6%	249	93.5	81	81	83.7	25.5%	299	112.3	98	98
2	7-12	AZ-102	AZ-102	--	--	9/1/2006	2/1/2008	12/31/2009	1/10/2011	3.17	171	3.23	5.01E+06	134	30.9%	375	141	123	204	134	24.7%	469	176	153	251
3	13-19	AY-102/C-106	AY-102	--	--	10/1/2009	10/1/2010	1/10/2011	8/8/2012	1.95	381	2.08	3.82E+06	192	29.0%	584	219	191	395	193	23.8%	716	269	234	485
4[l]	20-31	AY-101/C-104[m]	AY-101	5/1/2007	5/1/2007	10/1/2010	6/1/2012	8/8/2012	6/8/2015	3.15	643	3.37	2.00E+06	359	32.4%	1,049	394	343	738	359	29.1%	1,167	439	381	866
5	32-35	SY-102	AZ-101	9/29/2010	10/1/2010	9/1/2012	4/1/2015	6/8/2015	4/16/2017	2.02	168	2.08	6.79E+05	133	6.1%	696	262	227	965	132	5.9%	696	262	227	1,094
Privatization Phase 1 Minimum Order (600 canisters of IHLW)																		965						1,094	
Privatization Phase 1 Extended Order																									
6	36-44	C-107[m]/AW-103 (35%)	AY-102	7/1/2012	7/1/2012	5/1/2015	2/1/2017	4/16/2017	5/14/18[n]	3.04	474	3.20	1.19E+06	287	29.3%	875	329	286	1,251	287	29.0%	884	332.5	289	1,383
7	45-50	AW-104/AW-103 (25%)	AW-104	3/1/2016	3/1/2016	2/1/2017	2/1/2018	5/14/18[n]	7/29/18[n]	3.01	150	3.06	3.57E+05	150	25.7%	548	206	179	1,430	150	22.5%	625	235	204	1,587
Privatization Phase 1 Extended Order																		465						494	
Privatization Phase 1 Total																		1,430						1,587	
DST Backfill for Phase 2[o]																									
8	--	U-109	--	7/19/2011	--	--	--	--	--	--	282	--		--	--	--	--	--	--	--	--	--	--	--	--
9	--	T-105	--	10/1/2011	--	--	--	--	--	--	107	--		--	--	--	--	--	--	--	--	--	--	--	--
10	--	T-102	--	1/1/2012	--	--	--	--	--	--	125	--		--	--	--	--	--	--	--	--	--	--	--	--
11	--	BX-104	--	7/18/2016	--	--	--	--	--	--	291	--		--	--	--	--	--	--	--	--	--	--	--	--
12	--	TX-101	--	10/18/2016	--	--	--	--	--	--	146	--		--	--	--	--	--	--	--	--	--	--	--	--
13	--	SX-102	--	6/3/2017	--	--	--	--	--	--	131	--		--	--	--	--	--	--	--	--	--	--	--	--
14	--	U-108	--	11/23/2017	--	--	--	--	--	--	298	--		--	--	--	--	--	--	--	--	--	--	--	--
15[p]	--	S-111	--	1/26/2018	--	--	--	--	--	--	561	--		--	--	--	--	--	--	--	--	--	--	--	--

[a] Dates are derived from the Mission Summary Diagram except for the start and end of vitrification which are derived from HTWOS. All dates are supported by glass volumes calculated with the glass properties model.
[b] The date where batch qualification has been completed and first batch of the batch group is ready to be delivered to BNFL (nine months prior to delivery).
[c] Total solids for batch group assuming expected retrieval efficiencies.
[d] Batch volumes delivered are 0.2 to 0.6 ML each including inhibited flush water.
[e] Based on delivered feed, including both solids and liquids, decayed to date of delivery.
[f] Glass production estimates based on the PNNL glass properties model (GPM). The GPM is used by Waste Feed Delivery to provide a conservative basis for planning the quantity of HLW feed required to meet the production needs of BNFL.
[g] Glass production based on Specification 1 of the BNFL contract. Specification 1 provides the upper limit of glass production for a given HLW feed.
[h] Not including glass frit
[i] Not including Na_2O and SiO_2
[j] Glass density = 2.66 MT/m^3
[k] 1.15 m^3 of HLW glass per canister. Number of canisters assumes expected retrieval efficiencies of sludge from source tanks. Due to rounding, the sum of canisters may not equal the total (cumulative).
[l] The minimum order of 600 HLW canisters is met about halfway through Batch Group 4. Batch Group 5 is included in the minimum order because it provides contingency feed to mitigate waste feed delivery risks.
[m] 85 percent of the sludge in these tanks is assumed to be retrieved and delivered to BNFL Inc. Retrieval efficiencies vary in other tanks.
[n] HLW vitrification rate starting on 3/1/2018 is about 8 times the Phase 1 rate.
[o] DST backfill list for Phase 2 is preliminary and subject to change.
[p] Retrieval of 18 other single-shell tanks containing HLW feed solids are started during Phase 1 in addition to the SSTs listed here. The 8 SSTs listed contain larger quantities of solids than the other SSTs retrieved during this time.

DST - double-shell tank
HTWOS - Hanford Tank Waste Operation Simulator
IHLW - immobilized high-level waste

Figure 4.1-2. Logic and Timing for Certification and Delivery of High-Level Waste Feed.



* Subsequent batches of the same qualified feed do not require additional certification.

** The minimum duration between successive transfers of HLW feed deliverys from the same tank of qualified feed must be consistant with the contract.

CHG = CH2MHILL Hanford Group, Inc.
DOE = U.S. Department of Energy
ORP = Office of River Protection
WTD = Waste transfer date.

Four technical uncertainties influence the probability of delivering HLW on time throughout Phase 1: (1) retrieval efficiency, (2) concentration of glass-limiting component(s) in delivered solids, (3) solubility of glass-limiting component(s) during the pretreatment washing process, and (4) solubility of limiting component(s) in glass. Retrieval efficiency estimates are based on calculations using models derived from scaled mixer pump tests. Iron in the waste has a very limited solubility in the pretreatment washing process, which significantly decreases the pretreatment uncertainty for Batch Groups 1, 2, and 3. Similarly, zirconium in the waste has a very limited solubility in the pretreatment washing process, which significantly decreases the pretreatment uncertainty for Batch Groups 4, 6, and 7. The zirconium content of Batch Groups 4, 6, and 7 is at or near the GPM limit.

Batch Group 5 presents the highest uncertainty overall. This batch group has the highest uncertainty in both the concentration of glass-limiting component (chromium) in delivered solids and in the solubility of chromium during the pretreatment washing process. Waste Feed Delivery's largest uncertainty is the ability to deliver a known mass of glass-limiting components from a specific tank. This uncertainty can be managed by adequately characterizing the sludge, meeting expected retrieval efficiencies, and planning contingency feed.

The potential benefits of blending waste are large. Blending of HLW in 241-SY-102 may reduce the Phase 1 HLW glass produced by about 200 canisters at a cost for treatment and disposal of approximately $2 to 3 million per canister (Crawford et al. 1999; GAO 1999). Without blending, waste from 241-SY-102 would have a 6 wt% WOL.

The expected HLW glass production if minimum WOL is just achieved as required by Specification 1 of the BNFL Inc. contract is shown in the right-hand six columns of Table 4.1-1. Under these conditions, approximately 1,100 canisters of IHLW are produced after delivery of Batch Group 5 and approximately 1,600 canisters at the end of Batch Group 7. Glass estimates using Specification 1 are higher than estimates using the glass properties model because of lower WOL. This difference in the quantity of IHLW produced for the minimum-order tanks is approximately 140 canisters of IHLW and approximately 170 canisters for all of Phase 1.

The WOL in Batch Groups 1 and 2 is limited by the sum of aluminum, zirconium, and iron oxides (21 wt%). An iron oxide concentration of 12.5 wt% limits Batch Group 3. Batch Group 4 is limited by a calcium oxide concentration of 7 wt%. The concentration and the Specification 1 limit of calcium oxide were used to simulate the effects of strontium addition to the waste as there is no limit for strontium specified and the two are chemically similar. Large quantities of strontium are used for pretreating Envelope C LAW feed. High chromium oxide concentration (0.5 wt%) limits the WOL in Batch Group 5. Waste oxide loading in Batch Groups 6 and 7 is limited by the zirconium oxide concentration of 10 wt%.

4.1.3 Feed Compliance With Contract Specifications

The HLW feeds will contain a mixture of solids and liquids. The solid fraction must meet the criteria set forth in Section C, Specification 8, of the contract for Envelope D solids. The liquid fraction must meet, with some minor exceptions, the criteria set forth in Section C, Specification 7, of the contract for Envelope A, B, or C liquids (RL 1996).

The analytical and radiological concentration limits from Specification 8 and the predicted solids compositions for the nine batch groups of Case 3S6E are presented in Tables 4.1-2, 4.1-3, 4.1-4, and 4.1-5. These tables respectively correspond with Tables TS-8.1, TS-8.2, TS-8.3, and TS-8.4 of Specification 8. In these four tables, a shaded cell identifies any component that is out of specification and bold font identifies components within 50 percent of a specification. The concentrations of unwashed solids in the batch groups are listed in Table 4.1-6.

The data presented in Tables 4.1-2 and 4.1-3 represent the concentration of non-volatile and volatile components in the HLW feed for Case 3S6E. These data indicate that all of the criteria from Tables TS-8.1 and TS-8.2 of Specification 8 are met for the solids in the feeds, with the exceptions of vanadium in Batch Groups 6 and 7. The vanadium concentration may exceed the limit by a value ranging from 10 to 100 percent. Batch Group 3 is within 60 percent of the limit for carbonate. Batch Group 6 is within 75 percent of the arsenic limit and within 50 percent of the thallium limit.

Table 4.1-2. High-Level Waste Feed Unwashed Solids Maximum Non-Volatile Component Composition - Case 3S6E.
(grams per 100 grams non-volatile waste oxides).

Non-volatile element	Maximum (from Spec. 8)	Phase 1 Minimum Order					Phase 1 Extended Order	
		Batch group 1 AZ-101	Batch group 2 AZ-102	Batch group 3 AY-102/ C-106	Batch group 4 AY-101/ C-104	Batch group 5 SY-102	Batch group 6 C-107/ AW-103	Batch group 7 AW-104/ AW-103
As	0.16	1.75E-02	1.05E-07	1.38E-36	2.50E-71	7.12E-04	**1.20E-01**	6.54E-02
B	1.3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.89E-02	4.32E-02
Be	0.065	5.27E-04	3.16E-09	4.16E-38	7.55E-73	2.17E-05	6.67E-03	3.65E-03
Ce	0.81	0.00E+00	0.00E+00	2.85E-41	2.84E-17	2.56E-05	1.23E-01	6.67E-02
Co	0.45	3.48E-02	2.09E-07	2.75E-36	4.99E-71	1.42E-03	2.44E-02	1.34E-02
Cs	0.58	5.06E-03	2.30E-03	2.34E-03	3.84E-04	3.26E-03	2.53E-04	6.94E-04
Cu	0.48	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.22E-02	6.67E-03
Hg	0.1	0.00E+00	0.00E+00	7.80E-03	1.65E-02	3.04E-08	9.18E-03	9.06E-09
La	2.6	1.14E-01	2.91E-01	1.41E-01	1.11E-01	9.53E-03	7.17E-02	3.18E-02
Li	0.14	2.23E-03	1.34E-08	1.76E-37	3.19E-72	9.06E-05	1.20E-02	6.56E-03
Mn	6.5	9.13E-02	1.85E-01	1.91E+00	9.15E-01	2.36E-01	2.30E-01	1.42E-01
Mo	0.65	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.09E-02	3.33E-02
Nd	1.7	8.20E-02	4.50E-07	6.46E-36	1.17E-70	3.34E-03	1.20E-01	6.54E-02
Pr	0.35	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pu	0.054	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Rb	0.19	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Sb	0.84	8.20E-02	4.50E-07	6.46E-36	1.17E-70	3.34E-03	8.43E-02	4.61E-02
Se	0.52	5.52E-02	2.25E-07	4.35E-36	7.90E-71	2.25E-03	2.08E-02	1.14E-02
Sr	0.52	1.91E-02	2.45E-02	3.31E-02	1.66E-02	4.96E-03	2.51E-02	6.45E-03
Ta	0.03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.96E-03	4.35E-03
Tc	0.26	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Te	0.13	5.85E-02	4.50E-07	4.61E-36	8.38E-71	2.38E-03	2.08E-02	1.14E-02
Th	0.52	3.75E-02	2.25E-07	2.96E-36	5.38E-71	1.53E-03	2.08E-02	1.14E-02
Tl	0.45	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	**2.39E-01**	1.31E-01
V	0.032	7.89E-04	4.73E-09	6.22E-38	1.13E-72	3.19E-05	**6.30E-02**	**3.45E-02**
W	0.24	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Y	0.16	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Zn	0.42	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.37E-02	7.50E-03

Table 4.1-3. High-Level Waste Feed Unwashed Solids Maximum Volatile Component Composition - Case 3S6E.
(grams per 100 grams non-volatile waste oxides).

Volatile components	Maximum (from Spec. 8)	Phase 1 Minimum Order					Phase 1 Extended Order	
		Batch group 1	Batch group 2	Batch group 3	Batch group 4	Batch group 5	Batch group 6	Batch group 7
		AZ-101	AZ-102	AY-102/ C-106	AY-101/ C-104	SY-102	C-107/ AW-103	AW-104/ AW-103
Cl	0.33	1.76E-03	9.29E-07	5.18E-05	4.63E-06	4.83E-04	1.14E-05	5.32E-06
CO_3^{-2}	30	1.91E-04	1.55E+00	**1.91E+01**	1.18E+00	6.50E-01	1.16E+00	4.79E-03
$NO_2 + NO_3$	36	7.38E-01	3.39E-02	2.22E-02	4.26E-02	2.70E-01	3.41E+00	6.09E-02
TOC	11	1.94E-01	1.47E-01	2.10E+00	3.24E-03	1.35E-04	6.71E-06	2.56E-03
CN	1.6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NH_3	1.6	0.00E+00	0.00E+00	2.76E-01	1.46E-01	3.23E-04	1.27E-01	8.72E-08

Table 4.1-4 shows the concentration of radionuclides in the solids and how they compare to Table TS-8.3 of Specification 8. This table indicates that for Batch Group 4, the ^{233}U specification may not be met. The ^{233}U in Batch Group 4 is about seven times the limit.

Table 4.1-4. High-Level Waste Feed Unwashed Solids Maximum Radionuclide Composition - Case 3S6E.
(Curies per 100 grams non-volatile waste oxides).

Isotope	Maximum (from Spec. 8)	Phase 1 Minimum Order					Phase 1 Extended Order	
		Batch group 1	Batch group 2	Batch group 3	Batch group 4	Batch group 5	Batch group 6	Batch group 7
		AZ-101	AZ-102	AY-102/ C-106	AY-101/ C-104	SY-102	C-107/ AW-103	AW-104/ AW-103
^{3}H	6.5E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
^{14}C	6.5E-06	3.26E-08	1.95E-13	1.55E-08	2.44E-07	4.48E-09	2.85E-08	2.86E-14
^{60}Co	1E-02	9.67E-05	9.55E-05	2.84E-06	1.73E-05	2.22E-06	3.52E-06	3.20E-09
^{90}Sr	1E+01	5.86E-01	4.63E-01	9.07E-01	2.01E-01	2.83E-02	1.07E-01	2.39E-04
^{99}Tc	1.5E-02	1.88E-05	1.77E-10	2.64E-06	3.75E-06	1.18E-05	3.93E-06	9.99E-07
^{125}Sb	3.2E-02	5.07E-04	4.55E-04	1.27E-06	7.22E-08	3.61E-06	2.40E-08	6.11E-09
^{126}Sn	1.5E-04	8.52E-06	6.19E-06	5.99E-06	2.00E-05	2.00E-06	3.87E-06	2.67E-09
^{129}I	2.9E-07	0.00E+00	0.00E+00	1.55E-08	3.13E-09	6.35E-09	3.33E-10	3.28E-16
^{137}Cs	1.0E+01	5.41E-02	3.89E-02	4.87E-02	7.55E-03	2.75E-02	2.23E-03	5.44E-04
^{152}Eu	4.8E-04	1.80E-05	1.18E-05	6.56E-06	1.20E-05	1.04E-06	1.15E-07	8.37E-09
^{154}Eu	5.2E-02	2.57E-03	1.27E-03	3.08E-04	4.56E-04	8.05E-05	4.10E-06	1.59E-07
^{155}Eu	2.9E-02	1.46E-03	6.43E-04	9.56E-05	1.23E-04	2.60E-05	1.16E-06	1.66E-07
^{233}U	9.0E-07	2.20E-08	1.08E-08	1.78E-09	**6.34E-06**	1.24E-07	9.55E-09	1.78E-09
^{235}U	2.5E-07	6.05E-09	2.90E-08	1.06E-08	6.10E-08	1.87E-09	4.37E-08	4.72E-08
^{237}Np	7.4E-05	2.52E-06	1.94E-06	1.91E-08	1.57E-08	1.68E-07	2.83E-09	4.49E-10
^{238}Pu	3.5E-04	1.79E-05	2.84E-05	1.64E-05	2.55E-05	8.31E-07	4.98E-06	8.08E-06
^{239}Pu	3.1E-03	1.18E-04	2.18E-04	3.54E-04	5.85E-04	3.34E-04	1.31E-04	7.95E-05
^{241}Pu	2.2E-02	5.75E-04	1.53E-03	6.17E-04	8.35E-04	2.09E-05	1.64E-04	3.06E-04
^{241}Am	9.0E-02	2.78E-03	2.40E-03	7.92E-04	8.72E-04	1.49E-03	1.27E-04	2.64E-07
$^{243+244}$Cm	3.0E-03	7.77E-06	4.51E-06	1.01E-05	1.71E-06	2.44E-07	3.64E-07	4.65E-10

Table 4.1-5 shows the concentrations of a select group of analytes. These analytes are drawn from Table TS-8.4 of Specification 8 and represent components that are also important to

HLW glass production but will not be used as a basis for determining whether the feed meets specification requirements. This table indicates that for Batch Group 5, the chromium specification may not be met. The chromium exceeds the limit by 30 percent. Batch Group 4 is within 80 percent of the limit for aluminum.

Table 4.1-5. Additional High-Level Waste Feed Composition for Non-Volatile Components - Case 3S6E.
(grams per 100 grams non-volatile waste oxides).

Non-volatile element	Maximum (from Spec. 8)	Phase 1 Minimum Order					Phase 1 Extended Order	
		Batch group 1	Batch group 2	Batch group 3	Batch group 4	Batch group 5	Batch group 6	Batch group 7
		AZ-101	AZ-102	AY-102/ C-106	AY-101/ C-104	SY-102	C-107/ AW-103	AW-104/ AW-103
Ag	0.55	0.00E+00	0.00E+00	0.00E+00	1.61E-20	6.74E-15	3.26E-02	1.79E-02
Al	14	1.88E+00	4.50E+00	**8.76E+00**	**1.16E+01**	3.75E+00	4.23E+00	4.32E-01
Ba	4.5	0.00E+00	0.00E+00	2.87E-03	1.24E-04	4.78E-03	6.10E-02	3.33E-02
Bi	2.8	0.00E+00	0.00E+00	1.52E-04	2.97E-03	7.10E-02	**1.65E+00**	1.42E-02
Ca	7.1	7.31E-02	1.91E-01	7.74E-01	5.08E-01	1.58E-01	2.14E-01	2.41E-01
Cd	4.5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.23E-03	6.13E-03	3.35E-03
Cr	0.68	2.56E-02	9.39E-02	2.43E-01	2.41E-01	**8.97E-01**	1.55E-01	1.44E-01
F	3.5	2.02E-02	1.90E-02	2.85E-02	7.04E-03	2.65E-02	1.03E+00	7.10E-01
Fe	29	3.00E+00	8.44E+00	**1.57E+01**	5.39E+00	8.36E-01	4.68E+00	4.36E-01
K	1.3	1.08E-01	9.22E-02	1.41E-01	1.71E-01	4.69E-01	5.44E-02	1.88E-02
Mg	2.1	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.22E-01	6.67E-02
Na	19	5.75E-01	2.38E+00	**1.51E+01**	**1.27E+01**	**1.41E+01**	6.27E+00	1.61E-01
Ni	2.4	1.76E-01	5.72E-01	1.88E-01	3.61E-01	3.49E-02	1.52E-01	1.77E-01
P	1.7	4.56E-03	2.74E-08	2.66E-01	1.28E-01	2.07E-01	**1.04E+00**	3.67E-02
Pb	1.1	5.89E-02	7.03E-02	5.47E-01	1.34E-01	6.29E-02	3.32E-01	6.89E-02
Pd	0.13	5.52E-08	3.31E-13	4.35E-42	7.90E-77	2.25E-09	5.48E-15	2.28E-59
Rh	0.13	1.32E-02	7.93E-08	1.04E-36	1.89E-71	5.38E-04	4.98E-02	2.72E-02
Ru	0.35	2.68E-02	1.61E-07	2.11E-36	3.84E-71	1.09E-03	6.23E-03	3.41E-03
S	0.65	4.25E-02	1.79E-02	1.79E-02	4.41E-03	7.04E-02	1.30E-02	4.07E-02
Si	19	2.76E-02	2.82E-01	2.45E+00	1.31E+00	1.71E-01	1.17E+00	1.47E-01
Ti	1.3	1.98E-02	1.19E-07	1.56E-36	2.84E-71	8.07E-04	1.15E-02	6.32E-03
U	14	3.16E-01	1.58E+00	6.39E-01	3.89E+00	1.39E-01	2.45E+00	2.56E+00
Zr	15	1.06E+00	1.17E+00	2.08E-01	**1.02E+01**	5.09E-02	7.44E+00	4.04E+00

There is a risk that WFD may not be able to consistently deliver solids that meet Envelope D and liquids that meet Envelope A, B, or C as required by specification 8 of the BNFL Inc. contract. The feed envelope assessments in Tables 4.1-2 through 4.1-4 and 4.1-6 indicate that the HLW feed from three out of seven batch groups may fall outside the envelope specifications for solids and outside all except two batch groups for liquids. Refinement of component partition factors between liquid and solid phases used for retrieval modeling is necessary to confirm the extent to which the composition of the retrieved waste may be out of specification.

Envelope D feed is projected to be out of specification in Batch Groups 4, 6, and 7 each in a single component. Batch Group 4 has a concentration of ^{233}U seven times the limit. Batch Groups 6 and 7 may have elevated vanadium concentrations of 100 percent and 5 percent above the limit. The reported vanadium concentrations are based on "less than" values from sample analyses and therefore should be viewed as upper bounds. Blending HLW source tanks not only increases WOL but has the additional benefit of reducing component concentrations of the feed.

However, even after blending waste from source tanks in Batch Groups 4, 6, and 7, HLW feed in the staging tanks may not meet feed specifications for Envelope D.

While clause H.43 in the BNFL Inc. contract provides some latitude for processing out-of-specification waste, it does not remove the risk of a rejected feed batch. Clause H.43 states that if (1) the waste can technically be processed and (2) the waste complies with facility permits and (3) the waste falls within BNFL Inc.'s facility safety authorization basis, then a treatment price will be negotiated based on incremental impacts to BNFL Inc. costs and processing rates. So, clause H.43 by itself does not remove any risk from delivery of tank waste out of specification. There are no specific criteria written for the assumption stated above. Nor are estimates available for the size of the incremental cost impacts as discussed in the previous paragraph.

The RPP Key Planning Assumptions (PIO 2000) guidance directs us to assume that delivered LAW and HLW feed that is within the BNFL Inc. facility permits and safety authorization basis will be accepted and processed by BNFL Inc. Therefore, it is assumed that no feed blending or adjustments are required.

It is the intent of CHG to deliver feed that meets contract specifications. However, if the feed does not meet the specifications, it will be processed under contract clause H.43 (PIO 2000). There are no plans to alter the waste composition to bring out-of-specification feed into compliance.

The HLW feed specifications should be modified so that the delivered HLW feed composition meets contract specifications. Specification 8 in the BNFL Inc. contract should be modified so that all Hanford tank farm waste, when retrieved to a staging tank, falls within component specifications.

The concentrations of solids in the HLW feeds are listed in Table 4.1-6 for Case 3S6E. Specification 8 requires that the unwashed solids concentration in the HLW feed be between 10 and 200 g/L. The solids concentrations for all of the batch groups, with the exception of Batch Group 4, fell well within this specification. The solids concentration of Batch Group 4 is within 3 percent of the maximum limit. In a previous revision of the TFC O&UP (Kirkbride et al. 1999) avoided this problem by splitting the large quantity of sludge (approximately 1,100 m^3 [300 kgal]) from tank 241-C-104 into two DSTs. The current staging plans for 241-C-104 and 241-AY-101 were specified by ORP (1999).

Table 4.1-6. Unwashed Solids Concentrations in High-Level Waste Batch Groups - Case 3S6E.

	Phase 1 Minimum Order					Phase 1 Extended Order	
	Batch group 1	Batch group 2	Batch group 3	Batch group 4	Batch group 5	Batch group 6	Batch group 7
	AZ-101	AZ-102	AY-102/ C-106	AY-101/ C-104	SY-102	C-107/ AW-103	AW-104/ AW-103
Volume of batch group (liters):	3.05E+06	3.23E+06	2.08E+06	3.37E+06	2.05E+06	3.20E+06	3.06E+06
Mass of solids (g):	1.02E+08	1.71E+08	3.81E+08	6.53E+08	1.68E+08	4.74E+08	1.50E+08
Unwashed solids (g/L):	33.5	53.0	183.7	193.6	82.2	148.1	49.1

The analytical and radiological concentration limits from Specification 7 and the predicted liquid compositions for the nine batch groups are presented in Table 4.1-7. This table corresponds with limits presented in Tables TS-7.1 and TS-7.2 of Specification 7. The concentration of sodium is presented as well. In Table 4.1-7, the concentration of a component is compared to the maximum concentration allowed for that component for Envelopes A, B, and C. This comparison is made for each batch group. There are three columns that follow the concentration data from each batch group that correspond to the three envelopes. If the concentration for a component meets the criteria for an envelope, a "5" or an "8" is indicated in the cell of the table or the cell is left blank. If the cell is blank the component concentration is less than 50 percent of the specification limit. If the cell contains a "5" or an "8" the component concentration is greater than 50 percent or 80 percent of the specification, respectively. If the specification limit is not met, an "N" is placed in the cell and the background of the cell is shaded to call attention to it. Table 4.1-7 shows that the liquid fractions of Batch Groups 1, 2, 3, 4, and 6 do not meet the criteria for Envelopes A, B, or C. However, Batch Group 5 meets Envelope B and C specifications, and Batch Group 7 meets Envelope A, B, and C specifications.

Concentration data represented by zero values may be due to engineering assessments of sample data. The sample data may have been reported as less-than values or may not have been reported at all. The concentration data pedigree is addressed in Appendix C. The radionuclide data presented are decayed to the time of feed delivery to reflect what is spelled out in Specifications 7 and 8 of the contract.

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Table 4.1-7. Comparison of High-Level Waste Liquid Fraction with Criteria for Envelopes A, B, and C - Case 3S6E

From Tables TS-7.1 and TS-7.2 of Contract				Phase 1 Minimum Order																				Phase 1 Extended Order							
Chemical Analyte	Envelope A	Envelope B	Envelope C	Batch Group 1	A	B	C	Batch Group 2	A	B	C	Batch Group 3	A	B	C	Batch Group 4	A	B	C	Batch Group 5	A	B	C	Batch Group 6	A	B	C	Batch Group 7	A	B	C
	moles of analyte to moles of sodium																														
Al	2.5E-01	2.5E-01	2.5E-01	8.41E-02				2.34E-02				3.47E-02				8.23E-03				1.01E-01				8.01E-02				9.83E-02			
Ba	1.0E-04	1.0E-04	1.0E-04	4.09E-06				1.31E-13				3.53E-55				3.18E-103				3.78E-06				1.20E-06				4.00E-07			
Ca	4.0E-02	4.0E-02	4.0E-02	2.54E-06				4.66E-05				5.91E-05				8.88E-04				1.11E-04				3.46E-04				3.33E-04			
Cd	4.0E-03	4.0E-03	4.0E-03	8.72E-06				2.80E-13				7.52E-55				6.78E-103				8.71E-07				1.63E-07				7.37E-08			
Cl	3.7E-02	8.9E-02	3.7E-02	1.17E-03				1.11E-04				1.50E-02				6.08E-03				2.16E-02	5		5	1.71E-02				1.80E-02			
Cr	6.9E-03	2.0E-02	6.9E-03	3.10E-03				8.11E-03	N		N	2.73E-03				6.64E-04				3.49E-03	5		5	2.92E-03				2.46E-03			
F	9.1E-02	2.0E-01	9.1E-02	2.06E-02				2.32E-02				9.29E-03				3.19E-01	N	N	N	4.76E-03				1.74E-01	N	8	N	7.83E-02	8		8
Fe	1.0E-02	1.0E-02	1.0E-02	4.18E-05				8.01E-05				3.18E-05				3.56E-05				4.00E-05				8.11E-05				8.87E-05			
Hg	1.4E-05	1.4E-05	1.4E-05	0.00E+00				0.00E+00				2.54E-07				4.19E-06				2.67E-07				3.56E-08				1.66E-08			
K	1.8E-01	1.8E-01	1.8E-01	2.50E-02				3.36E-02				5.17E-03				2.53E-03				8.69E-03				2.82E-02				2.03E-02			
La	8.3E-05	8.3E-05	8.3E-05	4.67E-11				8.26E-06				1.15E-05				2.71E-06				1.65E-06				3.30E-06				2.71E-06			
Ni	3.0E-03	3.0E-03	3.0E-03	1.85E-07				1.51E-05				3.35E-04				4.10E-04				3.11E-05				1.36E-04				8.09E-05			
NO_2	3.8E-01	3.8E-01	3.8E-01	2.96E-01	5	5	5	2.78E-01	5	5	5	1.17E-01				2.36E-01	5	5	5	2.28E-01	5	5	5	1.92E-01	5	5	5	1.98E-01	5	5	5
NO_3	8.0E-01	8.0E-01	8.0E-01	2.55E-01				1.58E-01				7.07E-03				1.15E-01				3.33E-01				2.24E-01				2.46E-01			
Pb	6.8E-04	6.8E-04	6.8E-04	0.00E+00				0.00E+00				1.64E-04				2.02E-04				2.47E-04				9.08E-05				8.55E-05			
PO_4	3.8E-02	1.3E-01	3.8E-02	3.22E-03				5.96E-04				2.94E-02	5		5	1.16E-02				5.24E-03				3.46E-02	8		8	4.01E-03			
SO_4	1.0E-02	7.0E-02	2.0E-02	3.93E-02	N	5	N	7.92E-02	N	N	N	1.65E-02	N		8	1.50E-02	N		5	1.05E-02	N		5	8.49E-03	8			6.71E-03	5		
TIC	3.0E-01	3.0E-01	3.0E-01	1.18E-01				2.44E-01	8	8	8	3.61E-01	N	N	N	1.91E-01	5	5	5	5.22E-02				3.94E-02				7.34E-02			
TOC	5.0E-01	5.0E-01	5.0E-01	2.49E-02				5.56E-02				1.90E-01				8.81E-02				3.21E-02				6.86E-02				4.99E-02			
U	1.2E-03	1.2E-03	1.2E-03	4.46E-06				2.72E-04				7.27E-04	5	5	5	8.55E-05				2.08E-04				5.21E-04				2.28E-04			
Radionuclide	Becquerels of radionuclide to moles of sodium																														
TRU	4.8E+05	4.8E+05	3.0E+06	2.14E+06	N	N	5	3.29E+06	N	N	N	3.85E+05	8	8		4.96E+05	N	N		1.91E+05				1.26E+06	N	N		1.86E+05			
^{137}Cs	4.3E+09	2.0E+10	4.3E+09	1.23E+10	N	5	N	1.33E+10	N	5	N	5.97E+08				3.13E+08				1.30E+09				5.03E+08				5.07E+08			
^{90}Sr	4.4E+07	4.4E+07	8.0E+08	2.83E+08	N	N		3.13E+06				1.15E+07				8.14E+08	N	N	N	3.83E+07	8	8		1.12E+07				3.68E+06			
^{99}Tc	7.1E+06	7.1E+06	7.1E+06	2.32E+06				2.74E+06				2.42E+05				2.47E+05				6.73E+05				4.46E+05				4.49E+05			
^{60}Co	6.1E+04	6.1E+04	3.7E+05	1.58E+05	N	N		3.17E+02				1.22E+04				1.48E+04				7.02E+03				8.03E+02				6.97E+02			
$^{154}Eu + ^{155}Eu$	1.2E+06	1.2E+06	4.3E+06	1.10E+01				1.57E+06	N	N		8.26E+05	5	5		9.37E+05	5	5		1.09E+05				2.00E+06	N	N		3.14E+04			
From Spec 7.2.2.1	mol/L																														
Na	3 to 10			4.82	Y	Y	Y	2.36	N	N	N	1.48	N	N	N	1.59	N	N	N	4.67	Y	Y	Y	3.45	Y	Y	Y	8.18	Y	Y	Y

	Batch Group 1	Batch Group 2	Batch Group 3	Batch Group 4	Batch Group 5	Batch Group 6	Batch Group 7
Overall:	N N N	N N N	N N N	N N N	N Y Y	N N N	Y Y Y
N's	5 3 2	6 4 5	3 2 2	5 4 3	1 0 0	3 2 1	0 0 0
>80%	5 3 2	7 5 6	4 3 3	5 4 3	2 1 0	5 3 2	1 0 1
>50%	6 6 4	8 7 7	7 5 5	8 7 6	5 2 4	6 4 3	3 1 2

LEGEND:

- ☐ Meets Spec, < 50% of maximum
- 5 Meets Spec, > 50% of maximum
- 8 Meets Spec, > 80% of maximum
- N Does not meet Spec

4.2 TANK-SPECIFIC STAGING STRATEGY, EQUIPMENT, AND SCHEDULE

The tank-specific staging plan, retrieval and transfer equipment needed to support the staging plan, and the work execution schedule are discussed in this section.

4.2.1 Tank-Specific Staging Plan

The discussion below describes how each batch group is uniquely staged and delivered to BNFL Inc.

4.2.1.1 Minimum Order - Batch Groups 1-5. Batch Group 1: Tank 241-AZ-101 is the only source tank in this batch group. The waste is static and is staged in place for delivery directly to BNFL through the new AZ and AP valve pits. The tank is first in the HLW sequence because it has a large portion of the equipment required to retrieve the waste already installed. The waste contains large quantities of ^{137}Cs and ^{90}Sr, which cause problems during sampling because of high radiation dose rates involved. The liquid fraction of the tank is a portion of Envelope B feed for LAW treatment.

Batch Group 2: Tank 241-AZ-102 is the only source tank in this batch group. The waste is static and is staged in place for delivery directly to BNFL Inc. through the new AZ and AP valve pits. The tank is second in sequence because it also contains large quantities of ^{137}Cs and ^{90}Sr. The liquid fraction of the tank is also a portion of Envelope B feed for LAW treatment.

Batch Group 3: Tank 241-AY-102 is the only source tank in Batch Group 3. The contents of tank 241-C-106 were sluiced into 241-AY-102 during FY 1999. Batch Group 3 will be staged in 241-AY-102 for delivery to BNFL directly through the new AZ and AP valve pits. The WOL from waste in this tank will be limited by its iron concentration. Strontium and manganese precipitates from Envelope C pretreatment are assumed to start blending in the last three batches from this batch group and continue through Batch Group 4. The precipitation process and blending is performed in BNFL Inc.'s facility.

Batch Group 4: Wastes from tanks 241-AY-101 and 241-C-104 are blended to make Batch Group 4. After the retrieval system is ready in 241-AY-101, sludge in 241-AY-101 will be mobilized prior to retrieval of waste in 241-C-104. After waste from 241-C-104 is retrieved into 241-AY-101, Batch Group 4 is mixed and staged in 241-AY-101 for delivery to BNFL Inc. The delivery route goes through the central pump-pit above 241-AY-102 and then uses the same route as Batch Group 3.

Batch Group 5: Tank 241-SY-102 is the only source tank in Batch Group 5. After the retrieval system is ready in 241-SY-102 and after 241-AN-104 is emptied of LAW feed, the waste will be transferred as a slurry via a cross-site transfer line to 241-AN-104. The cross-site transfer will be the first time the slurry transfer is performed. The waste will be remobilized in 241-AN-104 and transferred into 241-AZ-101. Batch Group 5 will be staged in 241-AZ-101 for delivery directly to BNFL Inc. through the new AZ and AP valve pits.

4.2.1.2 Case 3S6E, Phase 1B-Extended Order - Batch Groups 6-7. Batch Group 6: Contents of tanks 241-C-107 and 241-AW-103 are blended to make Batch Group 6. Wastes from these tanks are blended to increase WOL and therefore decrease the amount of glass produced from 539 to 286 canisters. Tank 241-C-107 will be sluiced into 241-AY-102 after Batch Group 3 is delivered and the waste in tank 241-C-104 is retrieved. Batch Group 6 will be staged and fed to BNFL Inc. from 241-AY-102.

Batch Group 7: Wastes from tanks 241-AW -104 and 241-AW-103 are blended to make Batch Group 7. Waste from these tanks are blended to increase WOL and therefore decrease the amount of glass produced from 390 to 179 IHLW canisters. After the retrieval system is ready in 241-AW-104, a portion of the supernatant is decanted from the tank for LAW feed. At this time sludge in 241-AW-104 will be mobilized before transfer of waste from 241-AW-103 into 241-AW-104. After the waste in 241-AW-103 is retrieved into 241-AW-104, Batch Group 4 is staged in 241-AW-104 for delivery to BNFL Inc. The delivery route goes through valve pits in AW and AP farms and then through the new AP farm valve pit. Table 4.2-1 describes proposed staging action for each Phase 1 source tank along with process and equipment considerations.

Table 4.2-1. High-Level Waste Feed Preparation. (4 Sheets)

Batch group	Source tank	Staging tank	Proposed staging actions	Process considerations	Equipment considerations
1	241-AZ-101	241-AZ-101	• Stir up contents • Sample and certify • Remix contents and transfer slurry to BNFL Inc. (batchwise)	• Non-mobilized solids (retrieval efficiency) • Mixer pump performance (head) • Have spec. compliance issues on AZ-101 • Env. B – out of specification • 6 batches in batch group	• Has mixer pumps (need to test, W-151) • May need to replace mixer pumps after completion of test • W-521 provides transfer pump and I&C upgrades. • Assume equipment adequate for blending HLW (SY-102 and AW-103, if desired) • Down the road, failed equipment is replaced by Operations with no impact to schedule (for Phase 2) • W-521 Ready date May 2004 Op need date December 2004 • Mixer pump issue paper being drafted. - Need 3 to 5 m (10 to 15 ft) of head to operate mixer pump - Potential problem in mixing last third to half of tank
2	AZ-102	AZ-102	• Stir up contents • Sample and certify • Remix contents and transfer slurry to BNFL Inc. (batch wise)	• Non-mobilized solids (retrieval efficiency) • Mixer pump performance • Env. B – out of specification • 6 batches in batch group	• Need mixer pumps and transfer pumps • W-211 Ready date November 2003 Op Need date January 2005 • Mixer pump issue paper being drafted. - Need 10 to 15 feet of head to operate mixer pump - Potential problem in mixing last third to half of tank
3	AY-102 (with C-106)	AY-102	• Stir up contents • Sample and certify • Remix contents and transfer slurry to BNFL Inc. (batch wise)	• Non mobilized solids (retrieval efficiency) • Mixer pump performance • LAW Env. - Out of specification for Envelopes A, B, and C • 7 batches in batch group Note: Fe in solids results in little or no HLW impact from addition of Mn/Sr by BNFL Inc.	• Has one transfer pump (barely operational) • Has a mixer pump (failed) • Has a sluice pump • Need to install four 150-hp mixer pumps • Need to add a "sluicer" pump and transfer pump • W-211 Ready date March 2006 Op Need date April 2007 • Mixer pump NPSH issue, need certain liquid height to get desired flow. (May be less of a problem in this tank) • May not mobilize already-compacted AY-102 solids - Issue is ability to start mixer pump rather than the amount of AY-102 solids mobilized for feed to BNFL Inc. - High shear sludge - Any alternate retrieval technology would have to be demonstrated here - Could cause other impacts

Table 4.2-1. High-Level Waste Feed Preparation. (4 Sheets)

Batch group	Source tank	Staging tank	Proposed staging actions	Process considerations	Equipment considerations
					1. Waste homogeniety 2. Higher potential for batches to be out of specification (e.g., Ag).
4	AY-101	AY-101	(Leave contents in tank to blend with C-104) • Add fluid if necessary • Mobilize solids prior to receiving C-104 waste	• Mobilization efficiency (mixer pump performance) • Needs to be modified for use as sluicing receiver • Sluicing efficiency	• Has two transfer pumps • Needed capability is provided by W-521 Ready date July 2006 Op. need date April 2007 • Need to install three 150 to 300-hp mixer pumps • Need to add a “sluicer” pump and transfer pump • May be able to use one pump to support sluicing and transfer function
	C-104		• Retrieve C-104 in AY-101 • Periodically mix tank contents in AY-101 while retrieving C-104 • Mix to blend • Sample and certify • Remix contents and transfer slurry to BNFL Inc. (batchwise)	• Env. D –Out of specification • LAW Env. –Out of specification for Env. A, B, and C • 12 batches in batch group (all minimum batch size) • <u>Note:</u> Mn/Sr addition by BNFL Inc. will affect IHLW produced – approximately 60 more cans. • Beneficial to be able to certify at high solids loading and transfer with in-line dilution to meet maximum solids loading in contract • HTWOS doesn’t stop C-104 retrieval for mixing or interim sampling during retrieval, interim sampling could lengthen retrieval duration • Need to add OH during sluicing (C-106 experience)	• How will C-104 waste be retrieved? - Assume “past-practice” sluicing - Use C-106 data/lessons learned - Use AY-101 supernate as sluicing fluid - Add H_2O if more liquid is needed • W-523 (C-104) Ready date July 2006 Op Need date April 2007 • May demonstrate alternate retrieval technology in C-104 if available; remote vehicle with sludge pump and sluicing nozzles • AGA on alternate retrieval made no decision • Recent paper estimated retrieval at 2 times that of past-practice sluicing • Schedule issue regarding mixer pump installation and timing for sluicing - Mixer pump and sluiced liquid need the same risers • DST space may not be available to support complete C-104 retrieval (99.9%)

Table 4.2-1. High-Level Waste Feed Preparation. (4 Sheets)

Batch group	Source tank	Staging tank	Proposed staging actions	Process considerations	Equipment considerations
5	SY-102 (solids)	AZ-101	• Add transport fluid if needed • Mobilize with mixer pumps • Cross-site slurry to AN-104 • Mobilize and transfer to AZ-101 for staging • Sample and certify SY-102 in AZ-101 • Remix contents and transfer to BNFL Inc. (batchwise)	• How much can we mobilize? High shear strength sludge • IHLW produced is limited by Cr (~6% waste oxide loading) • Don't assume BNFL Inc. uses oxidative leaching to remove additional chromium • LAW – Out of specification Env. A • 4 batches in batch group	• Supplemental retrieval technology may be useful to achieve high retrieval efficiency (from SY-102) - Remove TRU-solids to prevent TRU-contamination of SWL added to tank after solids retrieval (SY-101 specification compliance issue, Phase 1 B prime specification compliance issue) • W-211 does not have supplemental technology in its baseline scope. • Staging equipment already in place in AZ-101and maintained by Operations Ready date July 2008 Op Need date September 2009
6	C-107	AY-102	• Retrieve C-107 into AY-102 (use sluicing parameters to model the retrieval) • 85% retrieval from C-107	• C-106 showed higher retrieval efficiency, we can expect to do better than 85% • May not have enough risers for sluicing receiver equipment and mixer pumps • Use inhibited H_2O as sluicing fluid if dilute non-complexed, low PO_4 waste is not available. • Need to add OH during sluicing (C-106 experience)	• Equipment already in place in AY-102 and maintained by Operations • W-523 (C-107) Ready date May 2009 Op need date Nov. 2009
	AW-103 (31.5% of total inventory)	AY-102	• Mix C-107 solids in AY-102 while transferring AW-103 • Mobilize and transfer AW-103 waste to AY-102 (use non-complexed low PO_4 concentrated waste as transfer fluid) • Sample and certify C-107/ AW-103 blend in AY-102 • Remix and transfer to BNFL Inc. (batchwise)	• Non-complexed low PO_4 available? • AW-103 sludge is high TRU, high F <u>Blended Waste</u> • Out of specification for Env. D • LAW – out of specification for Env. A, B, and C • 9 batches in batch group	<u>AW-103</u> • 2 mixer pumps; may need supplementary mobilization due to high shear sludge • ~ 31.5% retrieved (plan 90% retrieval eventually) • W-521 (AW-103) Ready date July 2005 Op need date Feb. 2007

Table 4.2-1. High-Level Waste Feed Preparation. (4 Sheets)

Batch group	Source tank	Staging tank	Proposed staging actions	Process considerations	Equipment considerations
7	AW-104 (solids)	AW-104	• Add transport fluid if needed • Mobilize with mixer pump before and during transfer of AW-103 waste into AW-104	• How much can we mobilize? High shear strength sludge • May be zeolite layer in sludge • Change to AW-104 LAW changes what liquid is available to mobilize solids	• Need mixer pump and decant pump • Existing transfer pump has failed • Need to replace transfer pump earlier to stage SWL for concentration in evaporator • There may be a zeolite layer in the middle of the sludge that causes problems with retrieval. • Tight schedule between LAW delivery and solids mobilization
	AW-103 (22.5% of total inventory)	AW-104	• Mobilize (use non-complexed low PO_4 concentrated waste received in tank as transport fluid) and transfer to AW-104 • Sample and certify AW-104/ AW-103 blend in AW-104 • Remix and transfer to BNFL Inc.	• Non-complexed conc. waste may not be available because of mixing SWL from different sources • Bottom sludge layers in AW-103 are harder to get <u>Blended Waste</u> • 6 batches in batch group	• <u>Alternate Strategy:</u> Deliver AW-104 solids with LAW feed? (combined delivery at appropriate times) - May not be blended with AW-103 solids if AW-104 LAW and HLW delivered together. • 2 mixer pumps, need supplementary mobilization – high shear sludge • ~ 22.5% retrieved (plan 90% retrieval eventually • Need to upgrade AW-102 Central Pump Pit (AW-102-02A), or replace SN-271 (between AW-A and AW-B) and renovate AW-A and AW-B jumpers to provide direct transfer route.

AGA = Alternative Generation and Analysis
DST = Double-shell tank
HLW = High-level waste
HTWOS = Handford Tank Waste Operation Simulator
I&C = Instrumentation and Control
IHLW = Immobilized high-level waste
LAW = Low-activity waste
NPSH = Net positive suction head
SWL = Saltwell liquid
TRU = Transuranic.

4.2.2 Equipment

Table 4.2-2 summarizes a preliminary assessment of the equipment needed for WFD was performed for Case 3S6E/Phase 1. Baseline change requests and project estimates have not been initiated to support Case 3S6E/Phase 1. Additionally it should be noted that the aforementioned costs do not include W-314 Phase 2 costs. At present it is assumed that the W-314 Phase 2 upgrades will be required to support the WFD mission regardless of variations in tank sequences. Details of how Case 3S6E/Phase 1 was interpreted for project actions are discussed below.

Table 4.2-2. Phase 1 Equipment Assessment for High-Level Waste Feed Delivery. (3 Sheets)

Tank or project number	Equipment required	Cost (in millions of dollars)
MINIMUM ORDER TANKS		
AZ-101 (W-521) • HLW source tank • HLW staging tank	• New transfer pump in AZ-02A central pump pit and jumpers • I&C system • *Replace existing mixer pumps previously installed by W-151.* • AY/AZ annulus ventilation upgrade	$17[1]
AZ-102 (W-211) • HLW source tank • HLW staging tank	• Two mixer pumps • New transfer pump and jumpers • I&C system	$16[1]
AY-102 (W-211) • HLW source tank • HLW staging tank • Slurry receiver for C-107 retrieval	• Four mixer pumps • New transfer pump and jumpers • I&C system	$22[1]
AY-101 (W-521) • HLW source tank (to be mixed with C-104) • *Slurry receiver for C-104 tank farm retrieval* • HLW staging tank	• Four mixer pumps • New transfer pump and jumpers • I&C system	$32[1]
C-104 (W-523) • HLW source tank	• New transfer pump, jumpers and pit • Sluicer, jumpers, pipelines, and pit • Associated equipment/I&C system • Uses AY-101 as slurry receiver tank	$83[1]
SY-102 (W-211) • HLW source tank	• Two mixer pumps • New transfer pump and jumpers • I & C system • *Supplemental retrieval system (not included in current scope)*	$20[1] ($5 – 10)[1]
EXTENDED ORDER TANKS		
C-107 (W-523) • HLW source tank • *To be blended with waste from AW-103.*	• New transfer pump, pipelines, jumpers and pit • Sluicer, jumpers, pipelines, and pit(s) • Associated equipment/I&C	$83[1]

Table 4.2-2. Phase 1 Equipment Assessment for High-Level Waste Feed Delivery. (3 Sheets)

Tank or project number	Equipment required	Cost (in millions of dollars)
AW-103 (W-521) • HLW source tank • Backup HLW staging tank • Two fractions of tank sludge to blending independently with sludge from C-107 and AW-104	• New transfer pump and jumpers • I&C system • *Supplemental retrieval system (not included in current scope*	$28[1]
AW-104 (W-521) • HLW source tank – sludge retrieval (to be blended with AW-103)	• Two mixer pumps • New transfer pump and jumpers • I&C system	$28[1]
W-314 Phase 1	• AN-A & B valve pit jumpers • Reroute Cross-site to AN-101 & 104 • Pipelines from AN-101 to AZ valve pit. • New AZ valve pit • Pipelines from AN-104-04A to new AP valve pit provided by W-521 • Pipelines from AZ V. P. to new AP valve pit provided by W-521 • AW-A and B valve pit jumpers • AY pipelines to AZ valve pit • AZ pipelines to AZ valve pit • MPS system	$157
W-314 Phase 2	• AN Tanks 102, 103, 105, 106 & 107 A pit drain seal, SPC & LD upgrades; new primary HVAC System, plus selected instrumentation, alarm, and electrical upgrades • AP Tanks 101, 102, 103, 105, 106, 107, & 108 selected pit drain seal, SPC & LD upgrades; new primary HVAC system, plus selected instrumentation, alarm, and electrical upgrades • AW Tanks 101, 102, 103, 105, & 106 selected pit drain seal, SPC & LD upgrades; new primary HVAC System, plus selected instrumentation, alarm, and electrical upgrades • AY Farm selected instrumentation, alarm, and electrical upgrades • AZ Farm selected instrumentation, alarm, and electrical upgrades • SY Tanks 101, 102, & 103 selected pits plus SY-A & B valve pit drain seal, SPC & LD upgrades; New Annulus HVAC system, plus selected instrumentation, alarm, and electrical upgrades • 244-S pit drain seal, SPC & LD upgrades; New Annulus HVAC System, plus selected instrumentation, alarm, and electrical upgrades	$127.8

Table 4.2-2. Phase 1 Equipment Assessment for High-Level Waste Feed Delivery. (3 Sheets)

Tank or project number	Equipment required	Cost (in millions of dollars)
W-521 (New AP valve pit)	• New AP valve pit • Two new pipelines to existing AP valve pit. • Upgrade existing AP valve pit jumpers and valve position indication • Tie required instrumentation into W-314 MPS • BNFL 4 pipelines (LAW & HLW)	$35[1]

HLW = High-level waste
I&C = Instrumentation and control
MPS = Master pump shutdown
SPC = Special pit conditioning
HVAC = Heating, ventilating, and air conditioning
[1]Cost shown is preconceptual rough-order-of-magnitude estimate. Costs are not validated.
Italicized text indicates work that is not currently part of project scope.

4.2.2.1 Potential Project Integration Issues. Project W-211 has completed the design and some procurements for a retrieval system in tank 241-SY-102. Costs incurred to date include design cost of $3.2M and procurement of $3.0M. If requirements change for the retrieval system in this tank, additional design and procurement costs could be incurred.

However, an evaluation needs to be performed to determine whether two mixer pumps with multi-level deployment are required to retrieve high-volume solids from 241-AW-103 and 241-AY-101. This work will be done as part of the early design phase for these tanks. If enhancement technologies, outside of the current project baseline, are required in addition to two mixer pumps with multi-level deployment per DST, the retrieval system costs for 241-AW-103 and/or 241-AY-101 could increase.

Project W-521 will modify the current 200 E Waste Transfer System design by adding a new valve pit north of the AP tank farm. The new valve pit would provide a transition point for new pipelines from the AN/AY/AZ to AP tank farm. The cost for the pit addition is provided in Table 4.2-2. Waste transfer pipelines will connect this pit to BNFL Inc. pipelines at their property boundary. Details of the BNFL Inc. interface are provided in ICD-20 (BNFL 2000).

4.2.2.2 Open Issues. A number of AGA studies are under way, or are planned, that address open issues related to DST infrastructure systems. The studies will assess the following systems: electrical power distribution, transfer system valve control/operation, primary ventilation requirements, annulus ventilation of aging waste tanks, transfer pump design, waste transfer system jumper needs, and sluicing/mixer pump interface at 241-AY-101 and 241-AY-102.

4.2.2.3 Primary Ventilation System Upgrades (Includes Toxic Gas Treatment). The table below provides a comparison of ROM cost impacts related to required tank farm exhauster system upgrades. At present the preliminary assessment of the DST primary ventilation system needs has concluded that upgrades will be required. The ROM cost provided assumes a replacement of the ventilation system from the de-entrainer through to the stack. The upgrade accounts for the addition of toxic gas treatment and monitoring.

Tank farm exhauster systems	Cost (millions)
AW Tank Farm	$10 - 30
AY/AZ Tank Farm 702-AZ	$20 - 30
SY Tank Farm	$10 - 30
TOTAL COST	$40 - 90

4.2.2.4 Basis for System Configuration. This section summarizes sources of failure in the feed delivery system hardware and how the failures are managed to ensure consistent performance.

Reliability, availability, and maintainability (RAM) analysis and Operations and Maintenance (O&M) concept documents are in preparation to quantify component failure frequencies, guide design redundancy, and quick-turnaround maintenance and repair strategies for retrieval and delivery of waste from the minimum order tanks. The current value place on privatization facility idle time (an ORP risk for failing to deliver feed) is $2.5M/day. Thus, the system configuration and degree of design conservatism is driven by the following:

Risk = Probability (RAM of design and O&M) X Consequences (idle penalty).
Note: Consequence = number of days idle x $2.5M/day.

There are five subsystems that are sources of component failure in the feed delivery system:

1. Transfer pumps (including tank specific I&C)
2. Mixer pumps (including tank specific I&C)
3. Transfer routes (lines, valves, jumpers, leak detectors, etc.)
4. Farm support systems (HVAC, water, nitrogen, electric, chemical makeup, etc.)
5. Instrumentation and control.

The philosophy used to minimize failure consequences in the tank farm design approach is summarized below.

4.2.2.5 Pumps. Pump design (items 1 and 2) is tank-specific. Although mixer and transfer pumps see little total operational time, failures historically have occurred and should be anticipated. Currently, the HTWOS model does not consider RAM inpacts on waste feed delivery. The effects of pump failures can be mitigated by providing multiple (>2) staging tanks and alternate/backup feed/source tanks. The failure of any one pump in the system can be overcome by employing redundant transfer pumps or delivering feed from another source tank or feed staging tank. The turnaround to replace a failed pump is approximately 70 days with staff and material prepared in advance (Shaw 1998, Appendix H, for basis and assumptions). Shorter turnaround times may be achievable given the high priority for avoiding idle facilities cost penalties.

The major portion of the Case 3S6E/Phase 1 HLW waste is stored in or will be transferred to the AZ and AY tank farms, and it will be staged therefore in AZ and AY tank farms. The alternate/backup staging tank for HLW will be in the AW tank farm. For Case 3S6E, when the 241-AZ-101 and 241-AY-102 tanks are emptied they will be used again for staging future feed for processing. Ensuring that multiple tanks are ready for retrieval and staging operations during the same time frame reduces the risk of a failed pump situation.

4.2.2.6 Transfer Routes. Transfer routes (item 3 above) are not as prone to failure as pumps unless the waste being transferred poses a high risk of plugging. Lines have failed in the past from plugging and from steam entering lines not designed to handle the temperature stress. These situations have resulted in failures/leaks. The current system generally is protected from line failures by redundant routes with some exceptions as noted below.

HLW tanks 241-AZ-101 and 241-AZ-102 use a common single line for a 60-m (200-ft) section of the HLW transfer route. Alternate source tanks located in the AW and AY tank farms can provide redundancy once the tanks have been upgraded with waste retrieval systems; upgrades will occur two years after HLW processing begins.

HLW tanks 241-AY-101 and 241-AY-102 use a common single line for a short section of the HLW transfer route. Alternate source tanks in the AW and AZ tank farms once the tanks have been upgraded with waste retrieval systems.

4.2.2.7 Farm Infrastructure. Failure of a tank farm infrastructure component (items 4 and 5 above) could result in removal of all tanks in a given farm from service under a worst-case scenario. The redundancy planned to mitigate this circumstance is to provide HLW backup feed staging capabilities in AW tank farm. Backup feed for HLW is assumed to be 241-AW-103 waste that could be delivered, if needed, directly from 241-AW-103 instead of blending it with other waste.

4.2.2.8 Equipment Conclusions. A single HLW route from 241-AZ-101 and 241-AZ-102 to the nearest transfer pit appears acceptable, because of the low potential for line plugging. However, plugging or failure of the first 60-m (200-ft) section of the route would disable initial HLW feed delivery. The AY tanks would not be available at the beginning of the campaign, and 241-AW-103 would not be equipped early enough to provide alternate feed. Options to provide alternate routes or feeds (pending further RAM work) are as follows:

– Provide two lines from the AZ tanks to the AZ transfer pit so that backup exists for the entire route. This option is not part of current project baselines.

– Accelerate construction of the 241-AW-103 mixer pump installation so that unblended feed from this tank would be available early in the schedule from an alternate farm not affected by an AY/AZ infrastructure failure. This option is included in the current project W-521 baseline as indicated on Figure 3.2-2.

An AY/AZ infrastructure failure (vent system) could take all the aging-waste tanks out of service. This risk appears acceptable for Phase 1. The fallback position would be to accelerate construction of the 241-AW-103 mixer pump installation so that unblended feed from this tank would be available early in the schedule from an alternate farm not affected by an AY/AZ infrastructure failure.

4.2.3 Schedule

4.2.3.1 Mission Summary. The waste feed delivery schedule projection for HLW indicates that BNFL Inc. operations will be supported continuously for Case 3S6E at Phase 1 rates. Operational need dates are established by a BNFL Inc. processing schedule calculated from HTWOS modeling with an allowance for time to transfer, blend, and certify waste as required. Construction dates in current project baselines support transfers, feed certification, and delivery of feed.

This schedule information is depicted on mission summary diagrams shown in Figures 3.2-1 and 3.2-2 (Section 3.2.3) for Phase 1 and Phase 1-Extended Order, respectively. The diagrams summarize the schedule interface between project actions and the need dates driven by the feed staging scenarios. Tanks supporting HLW feed delivery are shown on the lower portion of each diagram.

Figure 3.2-3 (Section 3.2.3) shows projected use of DSTs through the end of Phase 1. Notes on the figure indicate all tank-to-tank transfers for staging and delivery transfers to BNFL Inc. during Phase 1. Backfilling DSTs near the end of Phase 1 for early Phase 2 feed also is shown on the figure.

4.2.4 Tank Allocation Diagrams

Double-shell tank usage allocation diagrams found in Appendix H have been updated to include additional information regarding construction dates, transfer destination tanks, and tank volumes. Tanks of interest in all DST farms have been incorporated.

4.3 HIGH-LEVEL WASTE FLOWSHEET

See Section 3.3 for a description of the HLW flowsheet.

4.4 HIGH-LEVEL WASTE SENSITIVITY ANALYSIS

The sensitivity of the mission outcome to changes in key technical assumptions was assessed by running the HTWOS model with revised assumptions and comparing the results from the sensitivity cases to the baseline results. The major findings from this sensitivity analysis are summarized below. Results from Case 3S6E are provided in the discussion below as a reference for the comparisons.

Vitrification of HLW feed delivered through the last tank in the minimum order sequence (241-SY-102 in Figure 4.1-1), is completed by May 2017 producing a total of 960 IHLW canisters for the planning Case 3S6E (March 8 PIO Guidance case). The effect of changes to key assumptions on the IHLW canister count and completion dates for the minimum order feed tanks are given in Table 4.4-1. Descriptions of cases analyzed for this sensitivity analysis are shown in Table 1.3-1 and Figure 1.4-1. The following sensitivities are compared to the planning case 3S6E.

Table 4.4-1. High-Level Waste Feed Delivery Sensitivities.

Description	Sensitivity	Ramification
Case 3S6E R2A March 8, 2000 PIO Guidance	This is the result of implementing March 8, 2000 PIO guidance (planning case).	None – Produce 960 IHLW canisters by May 2017 assuming feed from minimum order tank.
Case 3S6E R2A Blending Option for 241-SY-102	The option of blending 40 percent of 241-AW-103 sludge (currently not planned for vitrification during Phase 1) with 241-SY-102 sludge is expected to increase the waste oxide loading in the blended waste. Blending may decrease the total number of IHLW canisters produced from these tanks by 200 at a life-cycle cost reduction of $2 to 3 million per canister.	Phase 1 tanks would increase feed for IHLW by 120 canisters and the corresponding contingency processing duration of 12 months. Overall mission reduction of 200 canisters and accelerate completion by 20 months.
Case 3S6E R2A Blending of manganese and strontium precipitates	If manganese and strontium precipitates produced from the pretreatment of Envelope C LAW waste are not blended with HLW feed (disposed as separate waste form or vitrified separately), then the amount of HLW glass BNFL Inc. produces could decrease. The planning case assumes blending of the precipitates with HLW feed.	Decrease IHLW by 60 canisters and accelerate completion by six months if disposed of as separate waste form. Insufficient information is available to authors at this time to quantify IHLW produced by separate vitrification.
Case 3S6B R1 Entrained solids	BNFL Inc. treatment of LAW entrained solids with HLW feed would have a minor impact on the amount of IHLW glass produced.	Increase IHLW by 10 canisters and delay completion of minimum order tanks by one month.
Case 3S6B R1 Slower ramp-up	Decreasing the HLW processing ramp-up rate to match the BNFL Inc. plan for ramp-up rate would defer IHLW production and delivery of later HLW feed tanks.	No change to IHLW quantity and delay completion of minimum order tanks by nine months.
Case 3S6C Early start	The effect of starting HLW vitrification 17 months earlier than Case 3S6E is expected to be negligible since this schedule was supported during fiscal year 1999.	No change to IHLW quantity and accelerate completion of minimum order tanks by 17 months.

HLW = High-level waste
IHLW = Immobilized high-level waste
LAW = Low-activity waste.